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Vocational education has been identified as an important policy domain to address youth unemployment, but empirical evidence is scarce. This paper estimates the effects of vocational education on employment outcomes in Ethiopia, where institutional reform has been implemented for the last decade. Compared to workers with secondary general education, effects on the probability of workers with entry-level vocational education having full-time work, permanent jobs, and formal jobs are not significantly positive. We also find the presence of displacement effects of expansion of vocational education on less educated workers. The estimate indicates that a 10% increase in graduates of vocational education in a local labor market, reduces the probability of having a formal job by 4.9% for male secondary graduates. Further expansion of vocational education may cause more adverse welfare impacts on less educated workers.

Keywords: Vocational education, Employment, Displacement effects, Youth, Ethiopia

JEL classification: I25, J13, J24

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October 30, 2017

Abstract
Vocational education has been identified as an important policy domain to address youth unemployment in low-income countries, but empirical evidence is scarce. This paper estimates the effects of vocational education on employment outcomes in Ethiopia, where institutional reform has been implemented for the last decade. Compared to workers with secondary general education, IV estimates of effects on the probability of workers with entry-level vocational education having full-time work, permanent jobs, and formal jobs are not significantly positive. We also find that when the proportion of workers with vocational education increases and the number of training institutes in a local labor market is added, workers with lower-secondary education are less likely to have either a permanent job or a formal job. The estimate indicates that a 10% increase in graduates of vocational education reduces the probability of having a formal job by 4.9% for males. This supports the presence of displacement effects of expansion of vocational education on less educated workers. Though effects are currently small, further expansion of vocational education may cause more adverse welfare impacts on less educated workers.

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1. Introduction

While low-income countries, particularly sub-Saharan African countries, have experienced steady

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economic growth in the last decade, it has not benefited many workers with low levels of education. In particular, young people have been suffering from underemployment despite substantial improvements in access to secondary education over the last ten years (World Bank 2013). Statistics for the African labor market show that the younger generation is more likely to work in the informal sector with unstable contracts and lower earnings compared to their older counterparts (Ranis and Gollin 2014). To enhance youth employability, skills development has been considered one of the key issues in the United Nations' Sustainable Development Goals. Among several policies, vocational provisions in education systems are expected to train a large number of younger people to equip them with the skills required in the labor market, and some low-income countries have already started expansion and restructuring of vocational education (UNESCO 2012).

The recent increase in expectations of vocational education is not, however, underpinned by firm evidence of its effects. Indeed, recent studies based on training interventions in low-income countries indicate mixed results vis-à-vis its impacts on earnings. While community-based training programs for the youth increased the earnings of participants in Liberia and India (Adaho et al. 2014, Maitra and Mani 2014) and engagement in income generation activities in Uganda (Bandiera et al. 2012), a positive impact on earnings and expenditure was not found in Malawi (Cho et al. 2013). A government-initiated training program, as a social or labor policy, exhibited some effects on earnings but not on employment outcomes in the Dominican Republic (Card et al. 2011), while a related initiative generated significant effects on young women but not on men in Colombia (Attanasio et al. 2011). These results demonstrate that effects of vocational training are heterogeneous and may be functions of local labor market conditions, type and quality of training, and characteristics of trainees. Furthermore, non-school based training programs such as those just put forward differ from vocational education in terms of size, quality, and services to be supplied. Given the specific focus of training programs, participants are often restricted in location, gender, and wealth, while implementation of training tends to be well-administrated by trainers with bespoke skills. Vocational education, in general, has more diversity with respect to trainees' characteristics and quality of training, and vocational schools usually provide job placement services and/or official certificates of skills in addition to training. Therefore, evaluation of non-school based training is important to understand the impacts of that training in the country or sub-region where a program was conducted, but such evaluations are not directly applicable to vocational education.

There is a dearth of studies into the effects of vocational education in low-income countries. Kahyarara and Teal (2008) investigate returns to vocational education using firm-worker data in the Tanzanian manufacturing sector. While they find positive returns, they do not examine employment outcomes, which are a more relevant measure to observe the contribution

to reducing youth unemployment. Hicks et al. (2015) estimate the impact of vocational education in Kenya in the context of tuition subsidies for out-of-school youth but do not find significant impacts on most outcomes, including earnings and employment. Thus, the effects of vocational education are not clear in low-income countries. Based on national labor surveys, our study explores the effects of vocational education on employment outcomes with broad coverage in location, industry, and gender in Ethiopia. It is noted that Ethiopia has restructured its vocational education so that the curriculum reflects labor demands in different industries and students' competencies are evaluated by the national authority. Since these reforms are in line with the recent development of vocational education policy in developing countries, evaluation of the Ethiopian case provides insights into the effectiveness of the new vocational education system on youth employment. A study by Abebe et al. (2016) in Ethiopia shows that job application workshops and skills certification by their program improved the quality of jobs subsequently secured by participants.

Given the characteristics of labor markets in low-income countries, our analysis into the effects of vocational education considers two key issues. The labor market in Ethiopia is represented by a large informal sector, as is the norm in low-income countries. Since people can easily enter the informal sector by starting self-employed work with little capital, the unemployment rate is not very high in most low-income countries. For example, the average unemployment rate in sub-Saharan African countries is 5.5% based on the definition by International Labour Organization; this is similar to the world average of 5.7% (LABORSTAT, 2016). Therefore, whether one is employed (including self-employed) or unemployed is neither a good indicator to assess youth welfare nor to evaluate vocational education. Rather, job quality, measured in terms of earnings, stability of contracts, and working conditions are suitable as outcome variables. In Ethiopia, while 86.0% of the youth labor force (aged from 17 to 35) is employed, 45.7% of them are seeking additional working opportunities and 39.6% of them worked less than 35 hours a week according to the 2013 Labor Force Survey. In this paper, we use working hours (full-time or part-time), job sector (formal or informal), and contract duration (permanent or not) as indicators of job quality.

Secondly, we consider the possibility that expansion of vocational education causes an externality. While an increase in vocational-track graduates may improve the quality of employment of workers with non-vocational education and/or with vocational education themselves through complementarity of skills, it may also work conversely through substitution. Given difficulties in access to credit, the marginal product of labor in Ethiopian firms may be diminishing in the short run, and thus, an increase in labor supply with vocational education may not generate a proportionate growth in labor demand. As those who have completed vocational education are better supported in job search in general, workers who pursued a non-vocational

track are likely to be displaced. For a job placement assistance program in France, Crépon et al. (2016) demonstrated that in regions with larger numbers of program participants, workers who did not participate in the program were less likely to be employed. Further, the theoretical model proposed by Acemoglu (1999) generates a long-term externality caused by an increase in skilled workers leading to a rise of unemployment of both skilled and unskilled workers. Ignoring adverse general equilibrium effects leads to overestimation of educational effects, and misses negative effects on poverty reduction if those who have less education are affected.

In this paper, using large-sample national labor force surveys over an eight-year period, employment outcomes are compared between young workers who completed vocational education and those who completed secondary education considering years of education. The sample contains both pre- and post-reform graduates, and thus, average effects are estimated. Endogenous choice of education is controlled by instrumental variables, namely the number of vocational schools in a district and neighboring areas for the year when a worker was aged 16, while the possibility of endogenous choice of school location is also considered. Estimation results show that positive effects of vocational education estimated by OLS are not supported by the IV results. Although the IV estimates tend to be less precise than the OLS results, the effect on the probability of having a full-time job is significantly negative for both genders in comparison with higher-secondary graduates.

Externalities of upscale in vocational education are estimated based on two measures capturing the presence of workers with vocational education in the local labor market: proportion of workers with vocational education and number of vocational institutes in a *zone* (the second administrative unit between region and district). Applying within-zone estimation, we quantify association between time-variation of those measures and that of employment outcomes of secondary graduates. For endogeneity of those measures, we incorporated heterogeneous time trends in the estimation models, which ensure comparisons among zones with similar characteristics. With both of the measures representing presence of TVET graduates, we revealed a negative externality on lower-secondary graduates in acquiring a permanent job for both genders, and a formal job for males. The addition of one institute leads to a 2.7% fall in the probability of having a formal job for male lower-secondary graduates, and that of acquiring a permanent job by 1.2% regardless of gender. Effects are clearest one year after the creation of a new institute, though they were discernable for more than four years on the probability of acquiring a permanent job. Little evidence for an externality is found with respect to higher-secondary graduates. The results are robust to sensitivity analysis.

This paper contributes to the literature in two ways. To the best of our knowledge, this is the first study to empirically investigate externalities associated with vocational education. Differing from Crépon et al. (2016), vocational education facilitates skill development in addition

to matching assistance, and thus, a negative externality possibly incorporates consequences of expanding the supply of skilled workers, which has been extensively studied in developed countries (e.g., Acemoglu 1999). Though our study cannot isolate the externality caused by an increase in skilled workers, it provides a basis for future research into this issue. Secondly, this is a more comprehensive study of the effects of vocational education on employment outcomes in low-income countries in terms of sample size, coverage of regions, industries and gender. Though, as mentioned, the results will not be directly applicable to other countries, this study provides useful information about the impacts of relatively well-organized and well-implemented vocational education policy for other low-income countries that are currently preparing for reforms.

In the next section, vocational education in Ethiopia is briefly described in order to elaborate on the context. Based on this, the third section theoretically explores the role of vocational education on employment, and its possible externality-generating role in labor markets. The fourth section delineates the analytical framework, and results are presented in the fifth section. Finally, concluding remarks are offered in Section 6.

2. Vocational Education in Ethiopia

For a long time, up until the 1990s, the objective of TVET in Ethiopia was to assist those who had dropped out of general education; it was only allocated a small budget and was institutionally disorganized (Simazu 2014). Its role changed substantially after the government's 2002 educational program was initiated, with a clear statement that TVET could help supply skilled labor for the Ethiopian economy (MoE 2002). TVET was positioned as part of upper secondary education, in which students, having completed lower-secondary education, can enroll for up to three years. Since then, the number of TVET institutes and enrolled students has increased steadily with assistance from the German government.

Restructuring of the TVET system occurred in 2006 to increase the relevance of the skills developed through TVET, focusing more closely on those demanded in the labor market, and thus, responding to criticisms that skills acquired in TVET were not useful at work. This is to facilitate economic growth through supplying skilled workers as well as reducing poverty by enhancing the employability of the poor (MoE 2008). To make TVET "market driven," the government defined occupation standards in collaboration with the industry, and the competencies of trainees began to be assessed based on those standards. Completion of the program is linked to national assessment results and a certificate of specific skills is awarded to successful trainees, so that TVET explicates and codifies the competency of trainees (MoE 2008). The reform has

introduced an outcome-based approach, replacing the traditional curriculum-based approach. The scale of TVET institutes was further expanded with the restructuring: the number of TVET institutes increased from 316 in 2003/04 to 919 in 2014/15. The number of people enrolled in TVET was 352,114 in 2014/15, of which 52.4% are female, while gross enrollment in secondary school was 2.1 million (MoE 2016).

TVET institutes offer programs from level 1 to 5, where level 1 and 2 courses provide laborer-oriented skills, through to level 5, which is managerial-oriented. Following the German vocational education system, apprenticeships outside of a school are incorporated and supposed to take 70% of the training time. While it is occasionally indicated that employers, particularly in the private sector, are not willing to accept trainees bearing extra costs (Asrat 2014), some employers whom we interviewed considered apprenticeships to be an opportunity to assess the quality of potential employees. Though regional differences are large, with a higher share in urban areas, overall, 67.8% of trainees pursued apprenticeships according to government figures (MoE 2016). Skills assessment has been mandatory in order for TVET trainees to successfully complete training programs since 2012, and currently, trainees have to undergo assessment after they complete each level of the program. Thus, a trainee studying a program at level 3 will need to have passed assessments at levels 1 and 2. Among trainees in the regular TVET program, 59.4 % passed (MoE 2016).

In the Ethiopian education system, students who have completed lower-secondary school take a national examination. Those who score above a threshold (cut point) are permitted to enroll in higher-secondary school, while those who score below this threshold can choose to either stop education or study in TVET institutes. Cut points for TVET are occasionally set. For example, a cut point was set for TVET level 3 and above in 2011/12, which is lower than the cut point for higher-secondary education, whereas cut points were not set from 2012/13 to 2014/15[1]. Cut points have not been set for TVET levels 1 or 2 with the exception of some regions where the expected number of applicants far exceeded the capacity of TVET institutes (according to an interview with the Federal TVET Agency). Therefore, TVET level 3 and above is not open to all students who have completed lower-secondary education, while TVET level 1 and 2 are more accessible.

3. Conceptual Framework

3.1. Quality of Employment for Workers with Vocational Education

Vocational education in Ethiopia affects the subsequent quality of trainees' employment mainly

[1] Based on information from the National Examination Agency.

through three channels.

Development of Skills: As a core function, vocational education provides training in specific vocational skills. While it has been criticized as less relevant to the types of skills needed in firms and workshops, the new TVET system in Ethiopia has made substantial changes to meet labor market demands. With appropriate training, trainees are more likely to be employed as skilled workers in a relevant industry, earning higher wages than their unskilled counterparts. Given the technology gap between formal and informal sectors, skilled trainees are more likely to secure jobs in the formal sector, where demand for skilled workers is larger, than workers on a non-vocational track given similar cognitive ability. On average, earnings are higher and contract terms are longer in the formal, rather than the informal sector because employers in the formal sector are subject to labor regulations.[2] The effectiveness of this channel depends on the quality of training in vocational schools as well as the relevance of the curriculum to labor market demands.

Signaling Skills: In general, skills are not easy for an employer to observe prior to hiring a worker. The recent restructuring of the TVET system in Ethiopia has tackled this information asymmetry by creating a national certification system. Although this system codifies rough skill levels, it is comparable and based on clearly defined standards. Therefore, employers may choose TVET graduates over other workers with the same skills by virtue of the relative visibility of their skills.[3] Studies on job matching in online markets demonstrate that the probability for a newcomer of getting a job increases when individuals possess evaluations from former employers or third parties (Pallais 2014, Santon and Thomas 2016). Effective signaling facilitates job seeking, particularly in the formal sector, where skilled workers are demanded and the labor supply far exceeds the demand.

Matching with a Vacancy: Vocational schools traditionally facilitate matching of graduates with job vacancies by collecting vacancy information, and referring candidates to potential employers, with whom schools occasionally have established relationships. Since job placement assistance

[2] Several empirical studies indicate that the earnings gap between formal and informal sectors is small or nil at the margin, while observing a clear gap in terms of average earnings (Gunther and Launov 2012 and Nguimkeu 2014 for African countries). An empirical study in Ethiopia by Blattman and Dercon (2016) showed that those who were assigned to entry-level jobs in formal (beverages, clothing, and horticulture) industries did not earn more than those who were assigned to self-employed jobs. This indicates that for an entry-level, unskilled job in the formal sector, quality of employment is unlikely to be better than a self-employed alternative available for the same worker.

[3] In the Ethiopian system, anyone can take the national assessment. But since assessment requires fees, non-TVET graduates who are not mandated to take an assessment are less likely to do so.

programs are evaluated as effective in developed countries (Card, Kluve and Weber 2010), matching facilitation can be more effective in low-income countries where individuals have less access to media for the purposes of exploring, identifying and applying for jobs. Given graduates' skill specificities, vocational schools can be an important hub to link labor market entrants with employers searching for workers with specific skills. It is noted that apprenticeships facilitate effective matching by providing opportunities for employers to infer trainees' skills and for employees to gain an understanding of the working conditions. In our interviews with Ethiopian employers, many told us that they were duly motivated to cooperate in the apprentice program. Vocational education trainees may benefit more from networks of friends, in lieu of online access, since many classmates are looking for jobs in the same, or related, industry.

As explained in the previous section, the new Ethiopian TVET system started after 2006 and is designed to raise the quality of jobs that trainees will have after program completion. The labor surveys that we use in the following analysis cover the period from 2006 to 2015, and therefore, incorporate both TVET graduate under the new and old system. However, timing of adoption of the new system differs mainly by region, but there is institute-level variation as well due to heterogeneous institutional practices and resource constraints. Therefore, it is difficult to clearly identify those trainees who are in the new and old systems, and our results are based on a mixture of the two systems of TVET.

3.2 Externality: Quality of Employment for non-TVET Workers

Several labor market models suggest the possibility that an increase in TVET graduates affects labor market performance of non-TVET graduates as well as TVET graduates themselves. In this section, we review the theoretical foundations of externality focusing on impacts on employment status of affected workers.[4]

As described in the above subsection, the vocational education system in Ethiopia is expected to increase the supply of skilled workers through providing training and a signal of skills. In the simple labor market model, increased supply of skilled workers is followed by growth of vacancies for them, and thus, this increase in supply does not affect the unemployment rate of skilled and unskilled workers. However, in the United States, a steady increase in unemployment and widening wage disparities were observed among unskilled workers in the 1980s, in conjunction with significant growth of supply of skilled workers. The model of Acemoglu (1999) links those two changes and provides a theoretical underpinning of externality associated with

[4] Externality may emerge in the wages of competing workers. In the literature on migrant labor, the impact of low-skilled immigration on wages of native workers has been investigated. Cortes (2008) finds a negative impact on wages of native Hispanics in the U.S. market.

growing numbers of skilled workers. In his setting, there are two types of workers who differ in skills and they randomly meet with vacancies which also differ in required skill levels. Although high-skill jobs yield more output, firms choose to open an intermediate-skill job (middling job) which accepts both skilled and unskilled workers because the matching probability of a middling job is higher than that of a high-skill job which only matches with scarce skilled workers. An increase of skilled workers, therefore, raises the probability for vacancies to match with them and firms open high-skilled and low-skilled jobs instead of middling jobs. In the new equilibrium, unemployment rates of both workers are higher because of larger matching friction: high-skill jobs do not accept unskilled workers and skilled workers do not take low-skill jobs. Endogenizing job matching, Albrecht and Vroman (2002) shows the case where high-skilled workers take both high-skilled and low-skilled jobs, while low-skilled workers cannot match with high-skilled job. Consequently, the growth of skilled workers hurts the unskilled more intensively, since skilled workers have more chance of matching than the unskilled. These models suggest mechanisms of externality impacting on unskilled workers through job composition changes.

In the models incorporating diminishing marginal product of labor in firm production proposed by Michaillat (2012), growth of labor supply leads to displacement of workers competing in a labor market. In a standard matching model, such as Pissarides (2000), size of labor supply does not affect the equilibrium unemployment rate because the marginal product of labor is constant with labor input, and the number of vacancies is proportional to the size of labor supply in equilibrium. A constant marginal product of labor is drawn from the assumption that firms instantaneously rent capital when a vacancy is filled, and thus, if capital is fixed in the short run, the marginal product of labor is diminishing under a production function with constant returns to scale. In the model with decreasing marginal product of labor, growth of vacancies is less than proportional to the growth of labor supply. Therefore, workers compete for vacancies more intensively, and consequently, the employment rate of those workers decreases (see Appendix 1 for the model). In the context of the Ethiopian labor market, an increase in TVET graduates induces displacement of skilled workers including themselves.

Crepon et al. (2013) applies a model with diminishing marginal product of labor to examine the displacement effect of a job placement program, which is essentially the same as the matching support service in TVET. The theoretical mechanism of externality in their paper is as follows. By increasing search intensity, the matching support service increases the matching probability of the benefited job seekers. While this leads to increase of labor demand through reducing the hiring costs of firms, it grows less than proportionate to the increase in search intensity because of diminishing marginal product. Due to limited growth jobs, increase of total matches is smaller than increase of matches among benefitted job seekers, and hence, probability of finding a job for those who are not supported by the service decreases. (see Appendix 1 for the

model). In our context, increase of TVET graduates who are supported by institutes for job search may adversely affect job seekers without such supports.

4. Empirical Methodology

4.1 Framework

For estimating the internal effects of vocational education, we compare young workers who completed TVET levels 1 and 2 as their highest education with those who completed lower- and higher-secondary education, separately. The two comparisons differ in interpretation of results. Since students enroll in a regular program of TVET or higher-secondary education after they complete lower-secondary education in Ethiopia, a comparison with workers who terminate education after lower-secondary education measures effects of *additional* vocational education on labor market performance. Whilst a comparison with workers who completed higher-secondary education indicates *relative* effects of vocational education to general two-year education. For estimation of externality, we assume that workers with secondary education, both lower and higher variants, are the closest substitutes of those with TVET, and most susceptible to the negative externality associated with the expansion of vocational education.

Characteristics of the three subsamples may differ particularly in terms of innate ability. This is not only because of endogenous choice of education but the fact that, as noted in Section 2, the national examination distinguishes students who can enroll in a higher-secondary school from those who cannot. If most eligible students opt to enroll in higher-secondary school, there will be a clear distinction in examination performance between students enrolling in higher-secondary education and those who chose TVET level 1/2, to which no cutoff point is set for enrollment. Although the examination is designed to measure curriculum-based understandings rather than innate ability, there would be a close correlation between examination performance and ability of applicants. In contrast, there are no institutional factors generating discontinuity of ability between lower-secondary graduates and TVET. It is noted that discontinuity across the subsamples depends on the likelihood of qualified students choosing higher-secondary education instead of TVET or terminating education. Although we do not have direct information about the likelihood, we can conclude that the score does not dominate a choice, if there is a variable that is correlated with choice of education but not correlated with examination score. Therefore, an effective instrumental variable will provide indirect evidence showing imperfect discontinuity of ability between TVET and higher-secondary graduates.[5] Instrumental variables are discussed

[5] An effective IV must satisfy exclusion restriction and thus, it should not be correlated with ability

later in this section.

Outcome variables include probability of being employed and quality of job. The latter is our main outcome variable, since it is easy to start self-employed work in the informal sector with little capital, and education is less likely to affect the probability of being employed. In fact, unemployment rate is relatively low at 14.0% in urban areas in 2013 (Labor Force Survey 2013), proving that informal jobs are a safety net for most of people who cannot access formal jobs. The more relevant measure of employment is the quality of jobs, which is occasionally very poor because of little earnings, overly short or overly long working hours, instable contracts, and poor compliance with labor regulations. Based on subjective judgments, 45.7% of young employed workers answered they wanted additional work in 2013 (Labor Force Survey). We construct dummy variables representing whether work is full time or part time, in formal or informal sector, and a permanent contract or not, as outcome variables reflecting employment quality. Recent studies on formal and informal sector jobs have suggested that the earnings gap across sectors is not significant at the margin but average wages differ (see Blattman and Dercon 2016, and Ngimukeu 2014 for African cases).

Data form a repeated cross-section; outcome variables are flow values (employment status at one time) rather than stock values (e.g., employment duration for a certain period). Assuming that job seekers rationally maximize earnings over their entire careers, flow values do not necessarily represent their performance in the labor market. For example, in a market with a few high-wage vacancies and a large number of low-earning opportunities, the amount of time skilled workers spend unemployed tends to be longer than unskilled workers because of their high reservation wages. If this is the case, the estimated effect is biased downwards. Underestimation is serious when we count the informal sector job as a positive outcome of employment, since skilled workers are unwilling to take jobs in this sector. Our outcome variable of probability of being employed suffers from underestimation, whereas outcomes in job quality are less vulnerable to this problem, because a job in the formal sector, with full-time work and a permanent contract is favored by both skilled and unskilled workers. We consider that estimates of effects on job quality do not entail serious bias.

4.2 Data

We combined two datasets for empirical analysis. The main dataset comprises a series of national labor surveys, which cover urban areas. In Ethiopia, annual labor surveys, the so-named Urban Employment and Unemployment Survey, are conducted only in urban areas, while surveys

and examination score, whereas it must be correlated with choice of TVET. The same argument applies to the comparison between TVET and lower-secondary graduates. If there is a variable correlated with choice of lower-secondary education versus TVET, it is not the case that students choose education based only on the score.

covering urban and rural area, the Labor Force Survey (LFS), are conducted every five years. We accessed datasets for eight years, 2006 and from 2009 to 2015 inclusive, which includes one LFS in 2013. To ensure a consistent sample base, only urban observations are used. Main sample consists of 51,931 workers aged from 17 to 35, who completed TVET level 1 or 2, lower-secondary school or higher-secondary school, and those not in education at the time of the surveys.

The other dataset is a list of TVET institutes as of 2016, newly compiled by the Federal TVET Agency and supplemented through the author's data collection work. Because information of individual institutes is normally stored regionally, this represents the first national-level dataset with basic information on public and private institutes, such as year established, training courses and levels offered, number of students and location. Based on this list, we mapped the geographical distribution of TVET institutes at the district level (*woreda*, the third-level administrative region) from 1987 to 2016, excepting two small regions. Those data are used as an instrumental variable as well as an explanatory variable, as discussed later. Coverage of the list is high but not perfect: all institutes in the two small regions, Dire Dawa and Gumbella, and a few in other regions are not covered; overall, coverage is estimated to be 86.8%.[6]

4.3 Estimating Effects of Vocational Education

Using the repeated cross-sectional data, estimations are based on a linear probability model and a latent index model. The linear probability model is in the following form:

$$y_i = \beta TVET_i + \boldsymbol{X}_i\boldsymbol{\gamma} + \mu_t + \pi_s + \varepsilon_i, \qquad (1)$$

where y_i represents four types of dummy variable, taking one when an individual *i*: (1) is employed (including self-employed and unpaid family work); (2) works fulltime; (3) works in the formal sector; and (4) has a permanent contract. $TVET_i$ denotes an indicator that equals one when an individual *i* has completed TVET level 1 or 2 but not higher. Covariates X_i include socio-demographic characteristics such as gender, age, and marital status. Location fixed effects, π_s, are incorporated to control heterogeneity of the local labor markets defines at zone level *s*. *Zone* is the second-level administrative region; about three quarters of workers, as well as the unemployed, confine their job searches to these second-level domains[7]. Finally, μ_t is year fixed effects.

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[6] Total number of TVET institutes is based on the table compiled by the Federal TVET Agency in 2017, and *Educational Statistics Annual Abstract 2014/15* (MoE 2016). Specifically we used the latter for the figure in Oromia region, where we assume that the figure in FTA's table includes institutes that do not offer regular TVET courses.

[7] According to the Central Statistical Agency, there were 94 zones including special zones in 2013. The surveys in 2013 and 2014 that contains migration information indicate that among those who were active in the labor market for the last six months, 33.0% of them migrated across a district, including within and out of a zone, while 67.0% did not migrate after age 16. Given the fact that one-third of workers moved out of the district they lived, we chose a zone as a boundary of labor markets.

For the latent index model, we apply a probit form:

$$y_i = 1[\beta TVET_i \ + \ \boldsymbol{X}_i\boldsymbol{\gamma} \ + \ \mu_t \ + \ \pi_s \ + \ \varepsilon_i > 0], \qquad (2)$$

where the operator of RHS, **1**[.], takes one when a condition inside the brackets is satisfied, otherwise zero, and ε is an error term with standard normal distribution. The data pertains to a repeated cross-section sample of workers aged between 17 and 35. Therefore, the effects of vocational education at one point in time when they are aged between 17 and 35 are estimated, and β indicates an average effect. Individuals who are not active in the labor market are excluded from the estimations, because education does not affect employability of inactive youth.[8] In sum, we focus our analysis on workers who are active in the labor market, and thus, β indicates an average effect of active workers.

The variable TVET is endogenous in the sense that students with higher innate ability may choose to enroll in TVET. We apply instrumental variables to mitigate possible biases. Decisions to enroll TVET are affected by the proximity of TVET institutes from students' residences, given limited mobility for pursuing secondary education.[9] We construct variables indicating the number of TVET institutes in each district (*woreda*) and zone for the year that individual *i* was aged 16.[10] Specifically, they are the number of institutes per capita in a district and in all districts within a zone except one that they lived.[11] The location of TVET institutes may not be exogenous, as they appear to be established in cities with large populations where there are more employment opportunities. Such correlation does not appear if jobseekers freely move location to search a job, since a worker who lived in a rural district without TVET institute at aged 16 has same opportunity of job offer as another worker who lived in an urban district with an institute. Under the assumption that a zone well defines a local labor market, workers move in a zone regardless of a district they lived. Hence, location of institute is uncorrelated with

[8] We notice that there may be some discouraged young people who failed to get a job for a long time among the inactive observations. Discounting them as unemployed workers may cause bias. Without detailed job search records, however, we neither able to identify them nor estimate jobseeker's decisions to stop or continue a job search.

[9] Among our sample of TVET graduates used in the analysis, only 3.9% migrated before age 15 for education purposes.

[10] There is a problem in practice that the surveys do not contain detailed residence information (at the district level) for respondents aged 16, and we need to define IV using residence at the time of survey completion. As one third of the sample moved after age 16, this is likely to weaken correlation of the IV with choice of TVET. Under the prior assumption that the local labor market is defined by a zone, this problem does not cause violation of the exclusion restriction for those who moved within a zone, since presence of institutes is not correlated with employment probability within a zone. However, there may be correlation between them across a zone, and if workers tend to move from a rural zone to an urban zone, where more institutes locate and more employment opportunities exist, then estimate of β suffer from upward bias.

[11] Due to infrequency of population statistics, we used population in 2007 from *Population Census* to create number of institutes per capita. Since the number of institutes changes each year, adjustment by population in 2007 reflects average access to TVET institutes over time.

employment outcomes given controlling zone fixed effects. To test this assumption, we compared outcome variables across districts within the same zone for the six subsamples defined by education (lower-secondary, higher-secondary, and TVET) and gender. We detected no significant differences except two cases out of the 24 (four outcome variables × six subsamples), and in the two cases, the average outcomes in districts with TVET institutes are lower than those without institute, as opposed to expectation (Appendix 2).

Estimation is based on 2SLS and a bivariate probit model; in the latter, an additional equation that regresses the endogenous variable on instruments is jointly estimated with the main equation allowing correlation between residuals of the two equations.

$$y_i = 1[\beta TVET_i + \boldsymbol{X}_i\boldsymbol{\gamma} + \mu_t + \pi_s + \varepsilon_i > 0] \quad (3.1)$$

$$TVET_i = 1\left[\boldsymbol{V}_{k,t-age\ +\ 16}\boldsymbol{\delta} + \boldsymbol{X}_i\boldsymbol{\theta} + \tau_t + \omega_s + u_i > 0\right] \quad (3.2)$$

where $\boldsymbol{V}_{k,t-age\ +\ 16}$ denotes a vector of instrumental variables defined for district *k* in a year that an individual *i* was age 16. τ and ω are year and zone fixed effects, respectively. Equations are estimated given possible correlation between the two residuals (ε and u), denoted ρ, which causes correlation between *TVET* and ε.

4.4 Estimating Externalities

Externality of vocational education is estimated among the sample of workers with lower- and higher-secondary education. We take two approaches. In the first approach, the proportion of TVET graduates among substitutable workers is used as a variable to represent their presence in the local labor market:

$$y_i = \beta_0 + \beta_1 w_{s,t} + \boldsymbol{X}_i'\boldsymbol{\gamma} + \tau_t + \pi_s + \varepsilon_i, \quad (4)$$

where $w_{s,t} = \frac{\sum_i TVET_{i,s,t}}{\sum_i (TVET_{i,s,t} + nonTVET_{i,s,t})}$, and $nonTVET_i = 1$ if $TVET_i = 0$, and *vice versa*.

$w_{s,t}$ denotes the proportion of workers with TVET out of all substitutable workers (TVET and lower- or higher-secondary graduates) in zone *s* and year *t*. Since lower- or higher-secondary graduates can be considered to have different skills in the market, the model is estimated for them separately, and corresponding $w_{s,t}$ is used.[12] Given the assumption that a zone defines a labor market, β_1 indicates the external effect on secondary graduates, that is, the effect of changes in TVET graduates relative to secondary graduates on the latter's employment

[12] Theoretical models suggest that the proportion of TVET graduates is an appropriate indicator of the degree of externality. In the models put forward by Acemoglu (1999) and Albrecht and Vroman (2002), an increase in the fraction of skilled workers leads to a reduction of middling jobs through a rise in the probability to match with skilled workers. In the displacement model by Crepon et al. (2013), the higher the proportion of workers with placement service, the more intensive is the displacement of workers without service.

outcomes. If it is negative, then increases in the TVET proportion adversely affect the employment of other workers, and vice versa. Since zone fixed effects are controlled, identification of β_1 rests on time-variation of *w* within a zone.

Time-variation of *w* can be correlated with residuals if the proportion of workers with TVET increases when labor demand for workers with secondary education decreases. It may be the case that workers with TVET move to a zone where they expect growth of labor demand for themselves, and demand for secondary graduates' decreases at the same time in such a zone. Alternatively, the government may tend to build a new TVET institute in such a zone. In both cases, β_1 incorporates those effects and a negative coefficient may not necessarily equate to a negative externality. To investigate this, we estimated the association between the proportion of TVET graduates and their employment outcomes instead of secondary graduates', since the above cases imply that TVET graduates have better employment performance when their proportion increases. The results do not support the demand-driven hypothesis, as reported in the next section.

We can deal with possible correlation between changes of TVET proportion and changes in unskilled labor demand by comparing observations across zones with similar labor demand trends. This necessitates incorporating multiple time trends in equation 4, which are estimated over subsamples separated according to similarity in labor demand.[13] We assume that the urban population in a local market partly determines relative demand for skilled versus unskilled workers, since demand for skills is likely high in urban area where technology is more skill intensive.[14] We allow different time trends by size of urban population in a zone. Thus, the estimation model is

$$y_i = \beta_0 + \beta_1 w_{s,t} + \boldsymbol{X}_i'\boldsymbol{\gamma} + \tau_{j,t} + \pi_s + \varepsilon_i, \qquad (5)$$

where *j* indicates a subgroup of zones defined by quantile or 10 percentile of urban population size.

Besides, *w* may suffer from measurement errors, since it is created from the surveys based on random sampling rather than census data. Though there is no specific evidence to suggest correlation between sampling errors and labor demands for TVET graduates, it may cause spurious correlation. To reduce errors, only the zones that contain more than 50 observations with TVET and secondary education, denominator of *w*, are used for the estimation, and sensitivity of

[13] Such correlation means that time trends differ across zones and are correlated with changes in TVET proportion. With a single trend, heterogeneity of trends is incorporated in residuals and endogeneity emerges. By defining appropriate trends, correlation between TVET proportion and residuals disappear (Dube et al. 2010).

[14] An alternative strategy is to compare neighboring zones under the assumption that trends in a labor market are shared in geographically proximate zones. This is a common assumption in studies of policy impacts on employment in developed countries (Card and Krueger 2000, Dube et al. 2010). In our context, however, there are large heterogeneities in educational and economic backgrounds between urban and rural areas, while they are occasionally located side by side.

the condition is explored.

The second approach utilizes the number of TVET institutes in a zone instead of TVET proportion. In a local labor market, the number of workers with TVET changes through supply changes of new graduates and labor migration across markets. The number of institutes represents only supply changes, and this approach is more appropriate for evaluating the possible externality effect of the TVET policy since 2002, under which the scale of TVET has been expanded. The estimation models is

$$y_i = \beta_0 + \beta_1 l_{s,t-1} + \boldsymbol{X}_i'\boldsymbol{\gamma} + \mu_t + \pi_s + \varepsilon_i, \qquad (6)$$

where $l_{s,t-1}$ denotes the number of public TVET institutes in zone *s* in year *t-1*. β_1 indicates the effect of increasing the number of institutes on employment outcomes of secondary graduates. Since $l_{s,t-1}$ represents size of skilled labor supply rather than proportion of skilled workers, estimates indicate an externality effect caused by growth of labor supply. As per the first approach, zone fixed effects are incorporated, and therefore, identification of β_1 rests on time-variation of l_s within a zone. The process of l_s is not clear: while the government appears to choose a region without an institute to broaden geographical coverage of vocational education, it is plausible to assume that labor demand for TVET graduates affects location of a new institute.[15] If the latter case is true, equation 6 clearly underestimates β_1, and thus overestimates negative spillover. Whereas in the former case, it may overestimate the coefficient as new institutes may be built in zones with low demand for TVET graduates. To deal with the possible endogeneity problem, we take the same strategy as the first approach. That is, to test association between number of institutes and employment outcomes of TVET graduates, and to incorporate heterogenous time trends defined by urban population size in the equation 6.

5. Empirical Results

5.1 Descriptive Statistics

In the sample, workers were aged from 17 to 35. At the start of the sample period, graduates of TVET constituted 12.1% of individuals, and the remainder are graduates of lower-secondary (60.1%) and higher-secondary (27.7%) education. During the period of our analysis, there was a steady increase in the proportion of individuals who were lower-secondary graduates and a decrease in higher-secondary graduates. The proportion of TVET graduates remained stable from 2006 to 2015. The geographical distribution is similar between individuals who were TVET and lower-secondary graduates, while higher-secondary graduates tend to concentrate in the capital

[15] The Federal TVET Agency has been monitoring geographical coverage of TVET institutes at the district level to identify districts without TVETs (interview by one of the authors in August 2016).

city, Addis Ababa.

Table 1 shows the summary statistics of the three education groups. Unfortunately, the dataset contains little information regarding pre-education personal characteristics. The average age is 25 years old, except higher-secondary graduates who are 29 on average. The gender balance differs between the groups with females being marginally better represented than males amongst TVET graduates, whilst the opposite is the case in the two secondary education groups. For post-education characteristics, a significant gap in labor force participation exists, particularly among females of which TVET graduates are higher by around 10%. This indicates either that women with higher motivation to work are more likely to choose TVET or TVET motivated them to work, or both. In the following analysis, only individuals who participated in the labor market are considered in order to focus on impacts on active workers. Marital status and number of children also differ across the groups: TVET graduates are less likely to be married and have fewer children than lower-secondary graduates despite similar average age. Information on family backgrounds is also limited because of the survey design which collected information only from family members who are in the same household. It indicates that TVET graduates have parents with better education and higher income than lower-secondary graduates, while this is not necessarily so comparing with parents of higher-secondary graduates.

In the lower panel of Table 1, outcome variables are compared. As assumed, the majority of TVET graduates, 76.9% female and 81.9% male, were employed, and the male employment rate is lower than other workers.[16] TVET graduates clearly have better jobs on average; they are more likely to have a job in the formal sector and with permanent contracts.[17] Sector of employment is slightly more diverse for workers with TVET than those with lower-secondary education, the latter being more concentrated in services (Figure 1). Therefore, it is unlikely that differences in outcomes between the three groups of workers are generated by heterogeneous labor demands across industry sectors. However, higher outcomes of TVET graduates may be because of their better family backgrounds as seen above, and therefore, simple comparison may not show positive effects of vocational education.

5.2 Effects of TVET on Labor Market Outcomes

Estimated effects of TVET against lower- and higher-secondary graduates are presented in Tables 2 and 3, respectively. Columns 1 and 2 of Table 2 show the results of OLS estimation without controlling for potential endogeneity. Female TVET graduates performed better than lower-secondary graduates in all the outcome variables, particularly in having a permanent job and a

[16] In the UEUS and LFS, those who worked more than 4 hours in the last seven days including self-employed and unpaid family work are defined as employed.

[17] Definition of formal sector is based on two conditions; whether an enterprise keeps book account, or whether it has a license.

formal-sector job: in each case they are 20% more likely to have such jobs. Male graduates are also more likely to get a permanent job and a formal-sector job, though effects are not significant for probability of being employed and even negative for getting full-time work. Estimation using the IVs is not effective for males due to weak relevancy with choice of TVET, as such we report only the estimates for females. For all the outcome variables except one case, permanent jobs, estimated effects by 2SLS and bivariate Probit are insignificant, partly due to larger standard errors compared with the OLS estimates (Columns 3 and 4). Although the F statistics of the instruments exceeded the usual threshold of 10, large standard errors suggest weak relevancy of the IVs. However, it is noted that in five out of eight estimates using the IV, the point estimate of the TVET effect is negative which contrasts with the OLS estimates.

Similar patterns emerge for comparisons with higher-secondary graduates, though negative effects are more significant in IV estimates. The OLS estimates of TVET effects are positive in most cases (Columns 1 and 2 in Table 3). The IVs fit better with choice of TVET, and standard errors are smaller than their comparators in Table 2. In the bivariate Probit model, the effects of TVET on having a full-time job and a formal-sector job are negative and significantly different from zero for both genders, and the effect on securing employment including self-employment, is also significantly negative for females (Columns 5 and 6). The relevant magnitudes here are substantial: the probability that TVET graduates have full-time jobs is 22.9% lower for females and 28.0% lower for males; whilst the probability of having a formal-sector job is lower by 21.9% and 29.3% respectively. The fact that OLS estimates are biased upward may be opposite to our expectation, since ability of higher-secondary graduates are considered no lower than that of TVET graduates. Possible explanation is, for example, that TVET graduates are helped by their family more effectively for their job search.

The IV estimates demonstrate that in comparison with higher-secondary education, the effects of TVET on labor market outcomes are not positive, and they are rather negative for some outcomes, specifically the probability of securing full-time and formal-sector jobs. The comparison with lower-secondary education is equivocal due to weak relevance of the IVs, and further investigation is needed in this respect. It is noted that relevancy of the IVs is stronger among the sample of higher-secondary and TVET graduates than the sample of lower-secondary and TVET graduates. This means that a substantial number of students who are eligible to enroll in higher-secondary school chose to enroll in a TVET institute, which warrants overlap of innate ability, more precisely examination scores, between higher-secondary and TVET graduates.

5.3 Externality

A. Approach using proportion of TVET graduates

Equations 4 and 5 are estimated using the probability of secondary graduates having a formal-

sector job and a job with a permanent contract as outcome variables. In the benchmark models based on the equation 4, we find significant negative associations in three out of four specifications for lower-secondary graduates. Specifically, an increase in the proportion of workers with TVET versus lower-secondary graduates is negatively associated with the probability of the latter having both types of job (having a permanent job only) for males (females); see columns 1 and 3 of Table 4. On the other hand, the associations with employment outcomes of higher-secondary graduates are weaker and not significant for all combinations of gender and outcome (columns 5 and 7).

We also estimate models including heterogeneous time trends, which differ by quantile of urban population in a zone. Specifically, we form four groups of observations defined by quantile of urban population in a zone where they live, and observations have different year trends across the groups, which are estimated by year dummies. These dummies control four different trends for each survey year. Inclusion of heterogeneous time trends does not alter the main results. For lower-secondary graduates, signs remain negative and coefficient magnitudes do not decrease in all three specifications where negative associations are found in the benchmark model (columns 2 and 4, Table 4). For higher-secondary graduates, signs of all the coefficients become negative but remain insignificant (columns 6 and 8). Based on the heterogeneous time trend model, a 10% increase in the proportion of TVET graduates in a local labor market reduces the probability of getting a formal-sector job by 4.9% for male lower-secondary graduates, and the probability of getting a permanent job by 2.3% (1.8%) for females (males).

To explore the robustness of these results, we incorporate higher resolution time trends defined by 10 percentiles of zonal urban population, which means 10 different controls for each survey year. The main results do not change, although coefficient magnitude becomes larger and significance increases for male graduates of lower-secondary schools (Table A4 in Appendix 4). Furthermore, we change sample restrictions to observe whether our initial condition that zones with 50 or more observations are used for estimations affects the results. We tested five alternative thresholds, namely 30, 70, 100, 120, and 150 observations (Table A5 in Appendix 4). For females, the externality with respect to the probability of having a permanent job remains negative for all the alternatives and magnitudes tend to be larger as thresholds rise. Coefficients are significant under the thresholds from 30 to 120 observations. For males, effects for both a permanent job and a formal job stay negative in most cases, while magnitudes fluctuate somewhat. They are significant at least for the thresholds of 30 and 70. It is noted that a higher threshold does not necessarily leads to better estimates, since it rules out zones with small populations and thus, the results diverge from the average effects. These exercises demonstrate that negative externalities are not unduly peculiar to threshold selection.

Finally, we directly address our assumption that changes in the TVET proportion in a

zone are not a function of changes in local labor demands. Our test is based on the prediction that employment outcomes of TVET graduates improve when the TVET proportion increases, which is drawn from the null hypothesis that the TVET proportion is closely associated with labor demands. Using equation 4, the association between the TVET proportion and their employment outcomes is estimated. Two types of proportion are used: one among the pool of lower-secondary and TVET graduates, and the other among the pool of higher-secondary and TVET graduates. In the eight cases consisting of two outcome variables, two gender types and two types of proportion, associations are negative in seven cases and no associations are significantly different from zero (Table A6 in Appendix 4). Thus, this test does not appear to support the null hypothesis. There is a limitation to this test, however, which needs to be considered. When the increase in workers with TVET in a zone substantially exceeds growth of labor demands for them, that is, too many TVET graduates rush to a growing local labor market, their employment outcomes do not necessarily improve. However, as shown, labor movements across zones are infrequent: less than a quarter of workers moved beyond a zone in the 17 to 35 age range (see footnote 6), and thus, we consider that the results support our assumption.

B. Approach using number of TVET institutes

As an alternative approach, relationships between the number of TVET institutes and employment outcomes of secondary graduates are estimated based on equation 6. In the estimation models with a single time trend, the probability of having a permanent job is negatively associated with the number of institutes for females and male lower-secondary graduates, while for the other specifications including all the cases of higher-secondary graduates, associations are not significant (columns 1, 3, 5, and 7 in Table 5). To deal with heterogeneity of time trends, multiple trends defined via separate year dummies according to quantile zonal urban population are incorporated as per the approach taken in the previous subsection. Estimated coefficients remain negative with larger magnitudes and significantly differs from zero in the three cases of lower-secondary graduates and in the one higher-secondary case (columns 2, 4, 6, and 8). For robustness, models incorporating time trends defined by 10 percentiles are estimated, and results therein are stable (Table A4 in Appendix 4). Based on the model results in columns 2 and 4, the addition of one institute leads to a 2.7% fall in the probability of having a formal job for male lower-secondary graduates, and that of getting a permanent job for workers with lower-secondary education by 1.2% regardless of gender.

We explored associations between number of institutes and employment outcomes of TVET graduates to determine whether institutes tend to be built in zones with growing demands for those graduates. All the associations are negative, and they are significant for males (Table A6 in Appendix 4). This suggests that a zone where a new TVET institute was built tends to

experience a fall in labor demands for its graduates one year later, and it rather supports the opposite assumption that new institutes are built in a zone with zero or a small number of institutes if labor demands for skilled workers is stagnant in such a zone. These results do not provide evidence to suggest that labor demands influence the establishment of these institutions.

It is noted that because the number of institutes did not change every year in many zones, the time since the last change in number of institutes differs across zones. For example, there is a zone where a new institute was built three years ago with no change in the number of institutes for the last two years. Therefore, if the magnitude of externality differs by time after changes in labor supply, the above estimates are averages of short-run and long-run effects weighted by time-specific sample distributions. One may argue that identified displacement indicates only a short-run effect due to a transient mismatch between labor supply and demand which is manifest only until firms prepare for adding vacancies.[18] To understand temporal variations, the externality is estimated separately for the subsamples defined by years since changes in the number of institutes. Table 6 shows that estimates of effects emerged more than two years later, more than three years later, and more than four years later, as well as the benchmark specification that shows effects more than one year later.[19] The results vary by outcomes and gender. The magnitude of externality with respect to female workers getting a permanent job is similar, although significance decreases, while it increases and remains significant for externality in terms of male workers (panel B). An increase of one public TVET institute leads to a 1.2% reduction in the probability of having a permanent job, on average, more than one year later, and a 3.5% reduction more than four years (columns 5 and 8 in panel B). In contrast, the magnitude of the negative externality decreases and becomes positive for female workers in securing a formal-sector job (Panel A). Finally, the magnitude of the externality fluctuates for males with respect to getting a formal-sector job, and effects are significantly smaller than zero more than one year later and more than four years later. In sum, the negative externality vis-a-vis male workers remains for several years.

C. Interpretation and discussion

The results of the two approaches using different indicators that represent the presence

[18] An externality caused by diminishing marginal product of labor theoretically emerges only in the short run, since firms adjust their capital in equilibrium and then, the marginal product of labor remains constant under technology of constant returns to scale. Externality caused by a transient mismatch between supply and demand, however, lasts much shorter under the plausible assumption that adjustment of labor is quicker than that of capital. So, by investigating effects in some years after addition of an institute, we can observe whether the identified externality is solely generated by delay in labor adjustment and whether it is a very temporary phenomenon or not.

[19] Effects which emerged more than two years later are estimated using a subsample excluding zones where a new institute was built one year before the survey year. The same procedure is applied for the other estimates.

of workers with vocational education are quite similar. In both approaches, among lower-secondary graduates, a negative externality is present for both genders in terms of having a permanent job and for only male graduates in terms of having a formal job. By contrast, higher-secondary graduates do not seem affected by growth of TVET graduates. Since we found mixed evidence concerning the duration of the externalities, some identified effects may be short-run phenomena which disappear in the long-run. Specifically, the externality to male workers having both a permanent job and a formal job is clear for at least four years after increasing the number of institutes, whereas effects are more clearly identified one or two years after in the case of female workers. Such results indicate the possibility that the externality is an equilibrium effect predicted by the theoretical models, and further analysis is warranted to explore this.

The theoretical models suggest that there are three possible mechanisms of negative externality to lower-secondary graduates. With diminishing marginal product of labor, an increase in the number of TVET institutes reduces the probability of them being employed on permanent contracts and in the formal sector. According to the model by Creporn et al. (2013), more efficient job search supported by a TVET institute is concomitant disadvantage to lower-secondary graduates in finding such a job. Alternatively, the heterogeneous job model put forward by Acemoglu (1999) explains that firms have more jobs requiring bespoke skills in response to the growing supply of TVET graduates, and as a consequence, the number of low-skill jobs accepting lower-secondary graduates has gone down.

The results using number of TVET institutes suggest that the first mechanism worked, since size of TVET graduates rather than their proportion in a market is associated with externality in the first mechanism. The results in Table A6 in the Appendix support this interpretation. It shows negative associations between number of institutes and employment outcomes of TVET graduates, which are significant for males. Since the externality applies equally to TVET and lower-secondary graduates in the first mechanism, these results are consistent with the theoretical prediction. Likewise, both or either of the other mechanisms, search intensity and job composition, are likely to work given the association of externality with the proportion of TVET graduates. If information about market evaluation on skill levels of lower-secondary graduates relative to TVET graduates is available, we would know more about an underlying mechanism, since they have different implications vis-a-vis the relative skill levels of those who are affected: the first two mechanisms predict an externality to workers with the same skill level as TVET graduates, while the third variant accounts for displacement of workers with less skills.

Finally, our results suggest considering externalities in evaluations of policies to enhance employability of job seekers. A negative externality as identified herein indicates growth of skilled workers including those who are certified as skilled, or supports for job search adversely affects employment outcomes of workers without vocational education. Therefore, assessment of

programs designed to train large numbers of job seekers, with certification, and support for job placements, may suffer from overestimation of impacts if they are based on a simple comparison of workers with and without treatment. This is identical to the message that Crepon et al. (2013) emphasized for the French labor market.

6. Conclusions

This paper addresses the effectiveness of vocational education for reducing youth unemployment in Ethiopia, where reform of vocational education policy has been implemented with substantial expansion of capacity over the last decade. Focusing on the probability of having a full-time, permanent, or formal job, simple OLS estimates suggest positive effects for young workers with entry-level vocational education on most outcomes over workers with general secondary education. However, IV estimates occasionally indicate negative effects, with a significantly negative effect found for the probability of having full-time work for males and females with vocational education against higher-secondary graduates. Since the relevance of the instrumental variables with endogenous school choice is not very strong, further analysis is justified to better explore the robustness of these results.

We find that both the change in the proportion of workers with vocational education and the change in the number of training institutes in local labor markets are negatively associated with the probability of having a permanent job for workers with lower-secondary education, but not for those with higher-secondary education. More precisely, when the proportion of graduates on the vocational track increases (decreases) in a zone, lower-secondary graduates are less (more) likely to have a job with a permanent contract for both genders, and a job in the formal sector for males. This also applies for the number of training institutes: they support the presence of a negative externality to lower-secondary graduates. Since negative effects lasted for several years in some outcomes, they are not entirely accounted for by the inability of firms to quickly adjust labor demands according to growth of labor supply. Possible mechanisms are that labor demand did not grow in proportion to the expansion of vocational education due to diminishing marginal product of labor and consequently, lower-secondary graduates competing in local labor markets are adversely affected, possibly more seriously given weaker job search supports compared to vocational graduates. A diminishing marginal product of labor can be justified when firms suffer from difficulty in investment. An alternative mechanism is that the composition of jobs in labor markets changes so that more skilled jobs were created and replaced middling jobs, to which lower-secondary graduates are only accessible.

Our analysis indicates the possibility that the expansion of vocational education

adversely affects non-vocational track workers, particularly those who are less educated. While effects are relatively small, they may increase disproportionally as vocational education continues to expand. Furthermore, the result that adverse impacts are found for less educated workers implies welfare impacts for poor households. It is critically important to understand the duration and magnitude of these adverse effects in order to assess the effectiveness of vocational education on youth unemployment.

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World Bank 2013. *World Development Report 2014: Job*, Washington D.C.: World Bank.

Table 1 Summary Statistics (Top: mean, middle: standard deviation, bottom: number of observations)

	TVET graduates	Lower secondary graduates	Higher secondary Graduates
Worker's Characteristics			
age	24.83	24.84	28.74 ***
	(4.352)	(4.778)	(4.415)
	6332	31215	14384
female	0.521	0.434 ***	0.422 ***
	(0.500)	(0.496)	(0.494)
	6332	31215	14384
married	0.362	0.384 ***	0.463 ***
	(0.481)	(0.486)	(0.499)
	6332	31215	14384
# of children	0.712	0.836 ***	1.142 ***
	(1.016)	(1.134)	(1.216)
	3035	14868	7399
Father's education	3.973	3.509 ***	3.801
	(1.939)	(1.732)	(1.861)
	451	1860	1195
Mother's education	3.390	3.102 ***	3.166 **
	(1.729)	(1.518)	(1.599)
	461	1773	1209
Parents job	0.382	0.453 ***	0.291 ***
=1 if self-employed	(0.553)	(0.584)	(0.504)
	2403	11271	5359
Parent's income	989.0	812.2 ***	922.0
	(866.9)	(739.9)	(783.1)
	367	1306	680
Employment outcomes			
Working: female	0.769	0.711 ***	0.746 **
	(0.422)	(0.453)	(0.435)
	3296	13541	6070
male	0.819	0.842 ***	0.855 ***
	(0.385)	(0.365)	(0.352)
	3036	17674	8314
Fulltime work: female	0.534	0.509 ***	0.572 ***
	(0.499)	(0.500)	(0.495)
	3296	13541	6070
male	0.617	0.655 ***	0.701 ***
	(0.486)	(0.475)	(0.458)
	3036	17674	8314
Formal sector job: female	0.544	0.343 ***	0.458 ***
	(0.498)	(0.475)	(0.498)
	2712	10944	4259
male	0.534	0.378 ***	0.473 ***
	(0.499)	(0.485)	(0.499)
	2432	14221	5739
Permanent job: female	0.360	0.156 ***	0.263 ***
	(0.480)	(0.363)	(0.440)
	3296	13541	6069
male	0.326	0.166 ***	0.255 ***
	(0.469)	(0.372)	(0.436)
	3036	17673	8314

Note: ***, **, * indicates p-value of difference from mean of TVET graduates is less than .01, .05, .1, respectively. Number of children is counted only when observations are a household head or its spouse. Parent's education is only available for observations living with them at the time of survey. It is indexed as 1= 1 literacy, 2= primary first cycle, 3= primary second cycle, 4= lower-secondary, 5= TVET1&2, 6= higher-secondary 7= Diploma/TVET3, 8= TVET4, University degree and higher education. Fulltime work is defined as more than 30 hours of work in a week, and formal sector is defined as a job in a organization which either keeps a book or have a license by public authority or a job in a governmental organization.

Table 2: Estimated effects of TVET in comparison with lower-secondary graduates

	OLS		2SLS	Bivariate Probit
	Female	Male	Female	Female
	1	2	3	4
Panel A: Being employed				
Effects of TVET	0.050 ***	-0.015	0.372	-0.128
	(0.010)	(0.010)	(0.370)	(0.530)
R2	0.055	0.070		
F stat of Instruments			11.0	
pesudo-likelihood				-16465.7
N	16,837	20,709	15,763	15,763
Panel B: Fulltime work				
Effects of TVET	0.029 **	-0.032 ***	0.026	-0.069
	(0.012)	(0.011)	(0.409)	(0.208)
R2	0.043	0.058	0.043	
F stat of Instruments			11.0	
pesudo-likelihood				-18110.4
N	16,837	20,709	15,763	15,763
Panel C: Permanent job				
Effects of TVET	0.204 ***	0.161 ***	-0.193	0.676 ***
	(0.012)	(0.011)	(0.450)	(0.026)
R2	0.106	0.084		
F stat of Instruments			11.0	
pesudo-likelihood				-14429.2
N	16,837	20,709	15,763	15,763
Panel D: Formal job				
Effects of TVET	0.199 ***	0.151 ***	-0.030	-0.170
	(0.013)	(0.010)	(0.456)	(0.409)
R2	0.079	0.076	0.044	
F stat of Instruments			16.1	
pesudo-likelihood				-14115.9
N	13,656	16,652	12,783	12,783

NOTE: Only coefficients of TVET dummy are reported. The coefficients for bivariate probit model are transformed to marginal change of probability. Standard errors clustered by zone are in the parenthesis. F statistics for excluded instruments in the first stage are reported. * p<.01, ** p<.05, * p<.1.

Table 3: Estimated effects of TVET in comparison with higher-secondary graduates

	OLS		2SLS		Bivariate Probit	
	Female	Male	Female	Male	Female	Male
	1	2	3	4	5	6
Panel A: Being employed						
Effects of TVET	0.043 ***	0.011	-0.160	-0.252	-0.275 ***	-0.090
	(0.010)	(0.010)	(0.129)	(0.156)	(0.053)	(0.055)
R2	0.0496	0.0888	0.009	0.007		
F stat of Instruments			13.7	10.4		
pesudo-likelihood					-9329.6	-9164.5
N	9,366	11,350	8,863	10,663	8,863	10,663
Panel B: Fulltime work						
Effects of TVET	0.012	-0.020	-0.287 *	-0.523 ***	-0.229 ***	-0.280 ***
	(0.011)	(0.012)	(0.174)	(0.196)	(0.086)	(0.058)
R2	0.0401	0.0629				
F stat of Instruments			13.7	10.4		
pesudo-likelihood					-10502.2	-11434.7
N	9,366	11,350	8,863	10,663	8,863	10,663
Panel C: Permanent job						
Effects of TVET	0.154 ***	0.131 ***	0.066	0.170	-0.071	-0.123
	(0.013)	(0.011)	(0.150)	(0.171)	(0.050)	(0.084)
R2	0.0859	0.0805	0.076	0.071		
F stat of Instruments			13.7	10.4		
pesudo-likelihood					-9585.8	-10922.9
N	9,366	11,350	8,863	10,663	8,863	10,663
Panel D: Formal job						
Effects of TVET	0.146 ***	0.123 ***	0.116	-0.176	-0.219 *	-0.293 ***
	(0.015)	(0.012)	(0.228)	(0.310)	(0.118)	(0.085)
R2	0.0582	0.0687	0.058	0.006		
F stat of Instruments			8.0	8.5		
pesudo-likelihood					-7891.6	-8904.6
N	6,971	8,171	6,600	7,684	6,600	7,684

NOTE: Only coefficients of TVET dummy are reported. The coefficients for bivariate probit model are transformed to marginal change of probability. Standard errors clustered by zone are in the parenthesis. F statistics for excluded instruments in the first stage are reported. * p<.01, ** p<.05, * p<.1.

Table 4 Estimates of externality using proportion of TVET graduates

	Externality to Lower Secondary graduates				Externality to Higher Secondary graduates			
	Female		Male		Female		Male	
	1	2	3	4	5	6	7	8
Panel A: Formal job								
Proportion of TVET graduates	0.036	-0.032	-0.479 ***	-0.487 **	-0.097	-0.292	0.068	-0.130
	(0.119)	(0.118)	(0.169)	(0.184)	(0.262)	(0.296)	(0.272)	(0.315)
Control of Time variation								
year	Y		Y		Y		Y	
year*quantile of urban pop		Y		Y		Y		Y
R2	0.048	0.049	0.057	0.061	0.025	0.030	0.036	0.053
N	8272	8272	10,279	10279	2613	2613	3441	3441
Panel B: Permanent job								
Proportion of TVET graduates	-0.191 **	-0.225 ***	-0.175 **	-0.175 *	-0.063	-0.024	-0.083	-0.082
	(0.078)	(0.074)	(0.079)	(0.098)	(0.144)	(0.111)	(0.119)	(0.128)
Control of Time variation								
year	Y		Y		Y		Y	
year*quantile of urban pop		Y		Y		Y		Y
R2	0.059	0.062	0.051	0.053	0.039	0.049	0.048	0.055
N	10,081	10081	12634	12634	3868	3868	5262	5262

NOTE: Only coefficients of the variable represents proportion TVET graduates are reported. Standard errors clustered by zone are in the parenthesis. Observations in the zones where total of TVET and non-TVET observations is less than 50 are excluded. * p<.01, ** p<.05, * p<.1.

Table 5 Estimate of externality using the number of TVET institutes in a zone

	Externality to Lower Secondary graduates				Externality to Higher Secondary graduates			
	Female		Male		Female		Male	
	1	2	3	4	5	6	7	8
Panel A: Formal job								
Number of TVET institutes	0.002	-0.003	-0.012	-0.027 ***	-0.008	-0.015	0.013	-0.003
	(0.008)	(0.009)	(0.009)	(0.009)	(0.013)	(0.015)	(0.015)	(0.014)
Control of Time variation								
year	Y		Y		Y		Y	
year*quantile of urban pop		Y		Y		Y		Y
R2	0.051	0.053	0.057	0.060	0.0467	0.052	0.0537	0.059
N	10260	10260	13295	13295	4077	4077	5432	5432
Panel B: Permanent job								
Number of TVET institutes	-0.007 **	-0.012 ***	-0.008 **	-0.012 ***	-0.009	-0.011 **	0.005	0.000
	(0.003)	(0.004)	(0.003)	(0.004)	(0.006)	(0.005)	(0.006)	(0.007)
Control of Time variation								
year	Y		Y		Y		Y	
year*quantile of urban pop		Y		Y		Y		Y
R2	0.0555	0.059	0.05	0.052	0.059	0.067	0.052	0.057
N	12704	12704	16522	16522	5803	5803	7861	7861

NOTE: Only coefficients of the variable represents number of TVET institutes are reported. Standard errors clustered by zone are in the parenthesis. * p<.01, ** p<.05, * p<.1.

Table 6 Estimates of externality by years after changes in institute number

	Externality to Lower Secondary graduates							
	Female				Male			
	1+ years after	2+ years after	3+ years after	4+ years after	1+ years after	2+ years after	3+ years after	4+ years after
	1	2	3	4	5	6	7	8
Panel A: Formal job								
Number of TVET institutes	-0.003	0.022	0.021	0.104 *	-0.027 ***	-0.008	0.002	-0.097 ***
	(0.009)	(0.017)	(0.027)	(0.053)	(0.009)	(0.016)	(0.025)	(0.035)
Control of Time variation								
year*quantile of urban pop	Y	Y	Y	Y	Y	Y	Y	Y
R2	0.053	0.058	0.056	0.055	0.060	0.063	0.066	0.070
N	10260	8515	7497	6845	13295	11018	9633	8776
Panel B: Permanent job								
Number of TVET institutes	-0.012 ***	-0.012 *	-0.019	-0.012	-0.012 ***	-0.011 **	-0.033 ***	-0.035 ***
	(0.004)	(0.006)	(0.012)	(0.014)	(0.004)	(0.006)	(0.007)	(0.009)
Control of Time variation								
year*quantile of urban pop	Y	Y	Y	Y	Y	Y	Y	Y
R2	0.059	0.061	0.062	0.061	0.052	0.056	0.059	0.061
N	12704	10660	9448	8646	16522	13848	12230	11172

NOTE: Only coefficients of the variable represents number of TVET institutes are reported. The results in columns 1 and 5 are replicated from columns 1 and 3 in Table 4. The samples in the columns 2 and 6 are observations living in a zone where number of institutes increased more than two years ago and thus, it did not change in one year ago. Same for the samples for column 3, 4, 7, and 8. Standard errors clustered by zone are in the parenthesis. * p<.01, ** p<.05, * p<.1.

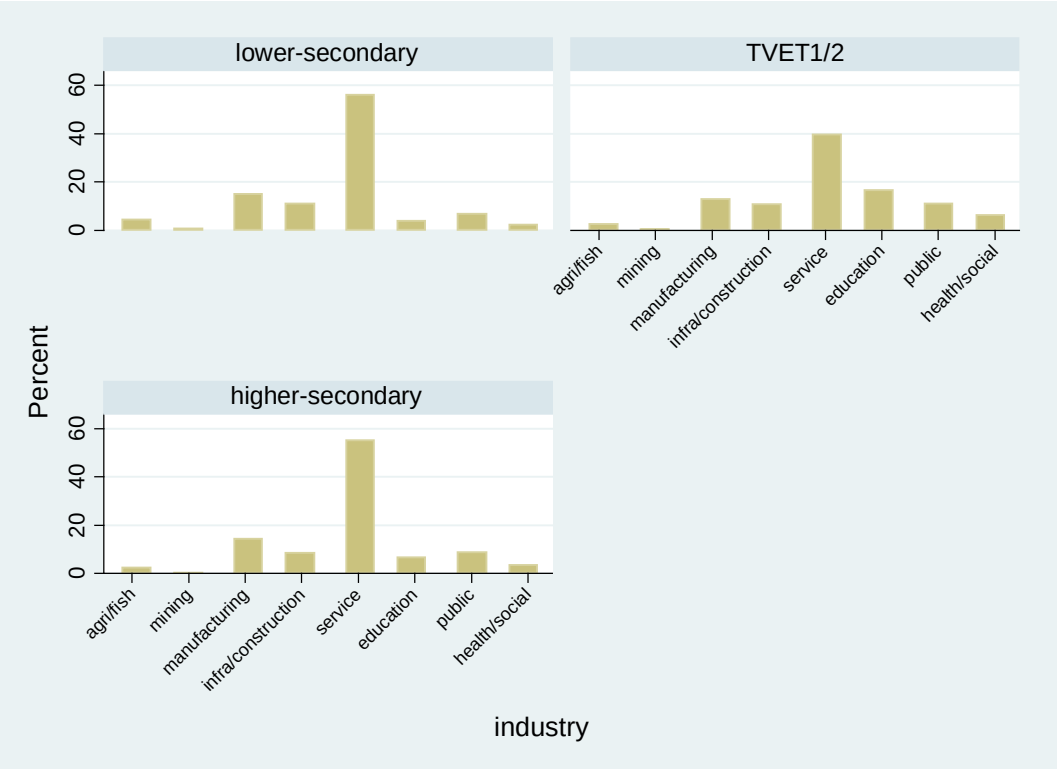

Figure 1: Sectors of employment

Appendix 1. Externality of growth of labor supply

In this appendix, we show the theoretical background of externality caused by growth of labor supply based on the model developed by Crepon et al. (2013) which incorporates decreasing marginal product of labor in firm production. We make a change in specification of production function so that marginal product of labor is decreasing with size of employment, while in the model of Crepon et al. (2013) and Michaillat (2012) it is decreasing with employment rate.

The model assumes homogenous workers and firms. Workers are either employed or unemployed with size E and U, respectively. Total size of labor is $L = E+U$, and denote employment rate $n = E/L$, and unemployment rate $u = U/L = 1-n$. The number of matches between unemployed workers and vacancies is given by standard matching function $m(uL, vL)$, where v denotes vacancies per total labor, and thus, vL is number of vacancies. The matching function is increasing and concave in both uL and vL, and homogenous of degree one. The probability that vacancies match with unemployed worker is $\frac{m(uL,vL)}{vL} = m\left(\frac{u}{v}, 1\right) \equiv q(\theta)$, where $\theta = \frac{v}{u}$ indicating labor market tightness. $q(\theta)$ is decreasing in θ. Unemployed workers find a job with probability $\frac{m(uL,vL)}{uL} = m\left(\frac{u}{v}, 1\right)\frac{v}{u} = \theta q(\theta) \equiv f(\theta)$, which is increasing in θ. Jobs is destroyed at an exogenous rate s.

A firm pays per period cost c to open a vacancy until it is filled, and once it is matched with unemployed worker, a firm pays fixed wage w and produce using technology with diminishing marginal product of labor.[20] Consider an aggregate production function:

$$y = aE^{\alpha}, 0 < \alpha < 1. \qquad \text{(A1)}$$

Marginal product of a filled job is $\alpha a(nL)^{\alpha-1}$. Thus, present value of a filled job is

$$rJ = \alpha a(nL)^{\alpha-1} - w + s(V - J), \qquad \text{(A2)}$$

where V is value of a vacancy and r is discount rate. Present value of a vacancy is

$$rV = -c + q(\theta)(J - V). \qquad \text{(A3)}$$

With the equations A2 and A3 with the free-entry conditions that indicate $V = 0$, we have following labor demand equation:

$$\alpha a(nL)^{\alpha-1} - w - c\frac{r+s}{q(\theta)} = 0, \qquad \text{(A4)}$$

[20] We assume fixed wage for simplicity. Incorporation of endogenous wage as a function of n and θ does not change the following argument. Specifically, labor demand curve, equation A4, shows decreasing relationship between n and θ. Michaillat (2012) shows labor demand function under diminishing marginal product of labor with endogenous wage.

where $c\frac{r+s}{q(\theta)}$ represents hiring cost. The equation A4 shows that labor market tightness θ is decreasing in employment rate, *n*. Since marginal productivity falls with rise of employment rate under diminishing marginal productivity of labor, firms can hire more labor as market tightness, and thus cost of hiring, becomes lower. This is intuition of downward slope of labor demand depicted in Figure A1.

Labor supply is obtained from steady-state conditions of labor flow, in which flow out of the pool of unemployed workers equals to inflow to it:

$$Uf(\theta) = sE.$$

Utilizing $U = (1-n)L$ and $E = nL$, we have

$$n = \frac{f(\theta)}{s+f(\theta)}, \qquad \text{(A5)}$$

which indicates labor supply with respect to market tightness. Since θ is increasing in *n* in labor supply function, the equilibrium employment rate and labor market tightness are determined by the two equations A4 and A5, which are depicted as solid lines in Figure A1.

The effect of growth of workers emerges through changes in the labor demand equation. In the equation A4, taking derivative with respect of *L*, we have

$$\frac{\partial\theta}{\partial L} = \frac{\partial\theta}{\partial q(\theta)}\frac{\partial q(\theta)}{\partial L} = -\left(\frac{c(r+s)(\alpha-1)\left(\alpha a n^{\alpha-1}L^{\alpha-2}\right)}{(\alpha a(nL)^{\alpha-1}-w)^2}\right)\frac{\partial\theta}{\partial q(\theta)}.$$

Since the first term in the RHS are positive and the second term is negative, we have $\frac{\partial\theta}{\partial L} < 0$. This means that labor demand function shifts left and equilibrium employment rate decreases (the dotted line in Figure A1). In the matching model with constant marginal product, the equation A4 does not include *n* and *L*, and thus labor demand is horizontal in the Figure A1, so that changes in *L* does not affect the labor demand curve.[21] That is, under constant marginal product, size of labor force does not affect labor supply and demand, and thus, plays no role in determination of the equilibrium employment rate. Labor demand grows at the same rate as growth of labor force, so that employment rate remains constant. With diminishing marginal product, growth of labor demand is less than growth of labor force since marginal productivity of labor falls as firms employ more workers, and employment rate decreases.

Original model of Crepon et al. (2013) incorporates heterogeneity of search intensity among job seekers. In their model, a fraction π of the workers took job placement service, and their search efforts, *e*>1, is larger than those of workers did not participate to the program, which is normalized to 1. Total search efforts are $u_e L = \pi e u L + (1-\pi)uL$, and total number of

[21] For example, instead of A1, production function is defined as $y = aE$. Labor demand equation is $\alpha a - w - c\frac{r+s}{q(\theta)} = 0$.

matches are $\mathrm{m}(u_eL, vL)$, of which $\frac{\pi euL}{u_eL} m(u_eL, vL) = \pi euLf(\theta)$ are for workers with the service. Their exit rate is $\frac{\pi euLf(\theta)}{\pi uL} = ef(\theta)$, while those who are without the service found a job at the rate of $f(\theta)$ and $ef(\theta) > f(\theta)$. Steady-state labor flow conditions are

$$\pi euLf(\theta) = \pi sE$$
$$(1-\pi)uLf(\theta) = (1-\pi)sE.$$

These equations lead to labor supply analogous to the equation A5:

$$n = \frac{f(\theta)}{s\left(\frac{\pi}{e}+1-\pi\right)+f(\theta)}. \qquad \text{(A6)}$$

As $\frac{\partial n}{\partial \pi} > 0$ given θ in the equation A6, increase of workers with placement service moves labor supply right (Figure A2). However, this shift causes reduction of θ in equilibrium because of downward slope of the labor demand curve. Decrease of θ results in fall of exit rate of workers without the service, $f(\theta)$. In the Figure A2, realized growth of employment rate (A) is smaller than the shift of labor demand curve (B), and the resulted gap represents size of displacement. It is interpreted that enhanced search intensity does not induce labor demands enough to absorb the additional labor supply that it created. Since those who are benefitted from matching services enjoy higher matching probability than those who are not done so, displacement of the latter is larger. It is noted that under constant marginal product of labor, shift of labor supply does not cause change of market tightness since labor demand is horizontal.

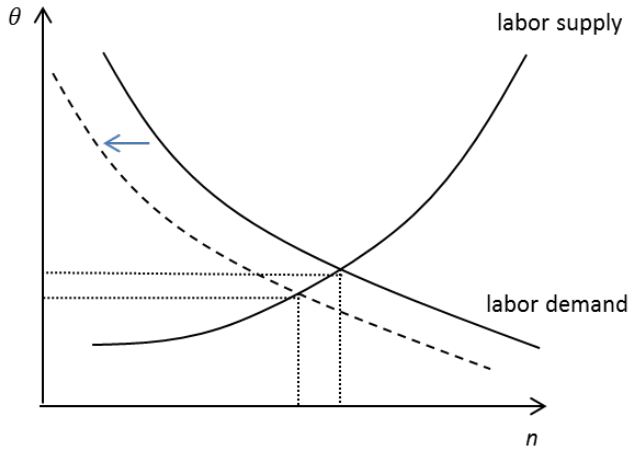

Figure A1 Increase of Labor Force

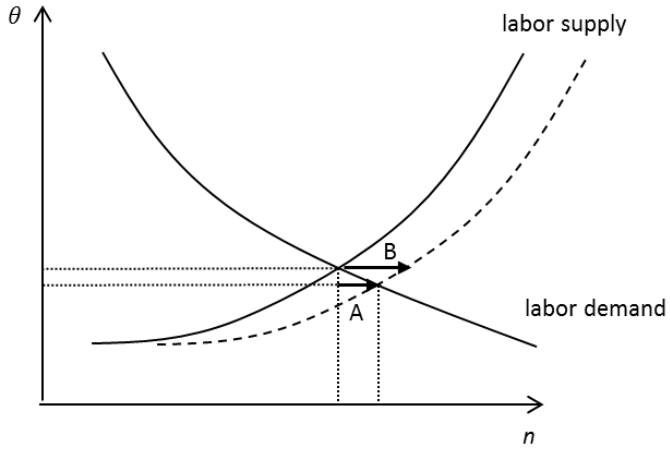

Figure A2 Increase of Search Intensity

Appendix 2. Comparison of employment outcomes across districts (*woreda*) in a same zone

Our assumption is that the local labor markets are defined by a zone, and workers search job with a zone. Therefore, there is no difference in employment outcomes by which district in a zone a worker lived at age of 16, and specifically, presence of TVET institutes in the district does not affect employment later. To test the assumption, we compare employment outcomes of workers lived in a district with TVET institutes and those lived in another district in a same zone without it. Among observations in the LFS2013 and UEUS2013, in which migration information available, only those who have not migrated are used for estimation, because location data before migration is available only at the zone level. This will not cause a problem, since employment outcomes do not differ by migration under our assumption that workers move freely in a zone.

The estimation mode is

$$y_i = \beta Inst_k + X_i\boldsymbol{\gamma} + \mu_t + \pi_s + \varepsilon_i, \qquad \text{(A7)}$$

where $Inst_k$ is a dummy variable equals to one when there exists a TVET institutes in a district *k* that worker *i* lived at age of 16. Notation of the other variables follows the main text. It is noted that inclusion of the zone fixed effect, π_s, ensure comparison within a zone. To exclude educational effects, the above model is estimated for separated samples by education.

Table A1 shows that differences are positive for male TVET graduates, while they are negative for female. Only probability for female TVET graduates of getting a permanent job is significant but negative, meaning that those who lived in a district with TVET institutes is less likely to have a permanent job than whose who lived in a district without it. We estimated differences for lower- and higher-secondary graduates, and found that majority of estimated differences are negative and no positive and significant differences are estimated.

Table A1 Within-zone estimates of differences in employment outcomes by presence of TVET institutes

dependet variable		TVET graduates		Lower secondary graduates		Higher secondary graduates	
		female	male	female	male	female	male
Being employed	presence of TVET institutes	-0.056	0.031	-0.029	-0.029	-0.018	0.023
		(0.096)	(0.065)	(0.041)	(0.026)	(0.069)	(0.053)
	R2	0.126	0.179	0.049	0.070	0.065	0.100
	N	872	800	3341	4819	1389	1875
Fulltime work	presence of TVET institutes	-0.027	0.085	-0.113 **	-0.005	-0.034	-0.001
		(0.114)	(0.101)	(0.046)	(0.037)	(0.085)	(0.069)
	R2	0.130	0.155	0.071	0.073	0.089	0.076
	N	872	800	3341	4819	1389	1875
Formal job	presence of TVET institutes	-0.170	0.085	0.004	0.005	-0.005	-0.032
		(0.113)	(0.107)	(0.044)	(0.034)	(0.085)	(0.069)
	R2	0.131	0.129	0.065	0.080	0.077	0.056
	N	845	770	3226	4565	1350	1796
Permanent job	presence of TVET institutes	-0.239 **	0.025	0.034	-0.009	-0.061	-0.004
		(0.111)	(0.094)	(0.033)	(0.027)	(0.066)	(0.059)
	R2	0.166	0.182	0.071	0.052	0.081	0.061
	N	872	800	3341	4819	1389	1875

Note: Robust standard errors are reported in the parentheses. ***: p<.01, **: p<.05 and *: p<.1.

Appendix 3. First stage results of Table 2 and 3

Table A2: First stage results of the 2SLS models

	with Lower secondary graduates	with Higher secondary graduates	
	Female	Female	Male
Panel A: Being employed, Fulltime work, Permanent job			
Number of institutions per pop	64.0 **	198.0 ***	200.0 ***
	(26.738)	(68.6)	(65.8)
Number of institutions per pop^2	-45497.6 ***	-111383.2 **	-109466.3 **
	(15197.300)	(44371.4)	(43482.9)
Number of institutions in a zone	0.010 *	0.071 ***	0.033 **
	(0.006)	(0.014)	(0.016)
Number of institutions in a zone^2	-0.002 ***	-0.008 ***	-0.001
	(0.001)	(0.001)	(0.002)
Adj R2	0.022	0.226	0.181
Fstat of the excluded instruments	11.0	13.7	10.4
Panel B: Formal job			
Number of institutions per pop	88.4 ***	167.5 ***	173.8 **
	(31.0)	(72.1)	(68.9)
Number of institutions per pop^2	-62147.5 ***	-106287.2 **	-103992.9 **
	(17226.8)	(44932.7)	(43174.7)
Number of institutions in a zone	0.013 *	0.065 ***	0.038 **
	(0.007)	(0.016)	(0.016)
Number of institutions in a zone^2	-0.002 ***	-0.007 ***	-0.002
	(0.001)	(0.002)	(0.002)
Adj R2	0.026	0.230	0.189
Fstat of the excluded instruments	16.1	8.0	8.5

NOTE: Only coefficients of the instruments excluded in the second stage equation are reported. They are the number of institutes per population in a district, its square term, number of institutes in a zone excluding those in a district where an observation lived, and its square term. Standard errors clustered by zone are in the parenthesis. ***, **, and * denote p<.01, <.05, and <.1, respectively.

Table A3: Results of the auxiliary equations of bivariate probit models

	with Lower secondary graduates	with Higher secondary graduates	
	Female	Female	Male
Panel A: Being employed			
Number of institutions per pop	235.7 *	406.4 **	366.7 *
	(139.9)	(167.1)	(192.3)
Number of institutions per pop^2	-164237.2 *	-222190.7 **	-274427.8 **
	(99070.9)	(105186.3)	(130832.8)
Number of institutions in a zone	0.047 **	0.158 ***	0.060
	(0.024)	(0.036)	(0.040)
Number of institutions in a zone^2	-0.007 ***	-0.017 ***	-0.002
	(0.002)	(0.004)	(0.005)
p-value of Wald test: rho=0	0.726	0.000	0.053
Panel B: Fulltime work			
Number of institutions per pop	259.3 **	434.3 **	358.6 **
	(111.8)	(176.7)	(178.1)
Number of institutions per pop^2	-172736.3 **	-237612.7 **	-266588.9 **
	(70965.0)	(113242.6)	(116467.1)
Number of institutions in a zone	0.048 **	0.169 ***	0.060
	(0.024)	(0.036)	(0.042)
Number of institutions in a zone^2	-0.008 ***	-0.019 ***	-0.002
	(0.002)	(0.003)	(0.006)
p-value of Wald test: rho=0	0.630	0.012	0.000
Panel C: Permanent job			
Number of institutions per pop	184.0 *	426.3 **	333.5 *
	(104.9)	(176.5)	(191.8)
Number of institutions per pop^2	-195157.4 **	-226751.4 **	-238814.4 *
	(86919.2)	(99053.2)	(130703.0)
Number of institutions in a zone	0.033 *	0.165 ***	0.038
	(0.019)	(0.036)	(0.051)
Number of institutions in a zone^2	-0.006 ***	-0.018 ***	0.000
	(0.002)	(0.003)	(0.007)
p-value of Wald test: rho=0	0.000	0.000	0.014
Panel D: Formal job			
Number of institutions per pop	327.4 **	481.4 **	359.4 **
	(148.6)	(186.7)	(166.2)
Number of institutions per pop^2	-176260.2	-247978.0 ***	-258624.5 **
	(129103.0)	(92195.9)	(105813.2)
Number of institutions in a zone	0.049	0.148 ***	0.070 *
	(0.043)	(0.047)	(0.042)
Number of institutions in a zone^2	-0.008 *	-0.017 ***	-0.002
	(0.005)	(0.005)	(0.006)
p-value of Wald test: rho=0	0.527	0.014	0.001

NOTE: Only coefficients of the instruments excluded in the main equations are reported. Standard errors clustered by zone are in the parenthesis. Results of the Wald test of null hypothesis that correlation coefficient between residuals of main regression and those of the auxiliary regression is zero are reported. ***, **, and * denote p<.01, <.05, and <.1, respectively.

Appendix 4. Results of robustness check

Table A4: Estimates of Externality: time trends by 10 percentiles of urban population

	Externality to Lower Secondary Graduates			Externality to Lower Secondary Graduates	
	Female	Male		Female	Male
	1	2		3	4
Panel A: Formal job					
Proportion of TVET graduates	-0.161	-0.623 ***	Number of TVET institutes	0.005	-0.025 **
	(0.156)	(0.139)		(0.009)	(0.010)
Control of Time variation			Control of Time variation		
year*10 percentile of urban pop	Y	Y	year*10 percentile of urban pop	Y	Y
R2	0.0553	0.0672	R2	0.057	0.065
N	8272	10279	N	10260	13295
Panel B: Permanent job					
Proportion of TVET graduates	-0.210 ***	-0.319 ***	Number of TVET institutes	-0.010 **	-0.012 ***
	(0.072)	(0.090)		(0.004)	(0.004)
Control of Time variation			Control of Time variation		
year*10 percentile of urban pop	Y	Y	year*10 percentile of urban pop	Y	Y
R2	0.0659	0.0577	R2	0.063	0.055
N	10081	12634	N	12704	16522

NOTE: Only coefficients of the variable represents proportion TVET graduates or number of TVET institutes are reported. Standard errors clustered by zone are in the parenthesis. In the specification of column 1 and 2, observations in the zones where total of TVET and non-TVET observations is less than 50 are excluded. * p<.01, ** p<.05, * p<.1.

Table A5: Estimates of Externality: alternative thresholds for sample selection

A: Female

	Externality to Lower Secondary Graduates, Female				
	>30 obs.	>70 obs.	>100 obs	>120 obs.	>150 obs.
	1	2	3	4	5
Panel A: Formal job					
Proportion of TVET graduates	0.002	-0.107	-0.085	-0.083	0.493
	(0.117)	(0.132)	(0.142)	(0.200)	(0.408)
Control of Time variation					
year*quantile of urban pop	Y	Y	Y	Y	Y
R2	0.049	0.051	0.047	0.047	0.049
N	9459	7074	6120	5,607	4,176
Panel B: Permanent job					
Proportion of TVET graduates	-0.165 **	-0.259 **	-0.305 **	-0.280 **	-0.202
	(0.071)	(0.097)	(0.122)	(0.129)	(0.168)
Control of Time variation					
year*quantile of urban pop	Y	Y	Y	Y	Y
R2	0.062	0.061	0.056	0.053	0.054
N	11704	8482	7062	6,487	4,828

NOTE: Only coefficients of the variable represents proportion TVET graduates are reported. Standard errors clustered by zone are in the parenthesis. Observations in the zones where total of TVET and non-TVET observations is less than 30 are excluded in the specification of column 1, and same procedure is taken according to number of observations shown in a heading for the specification of the other columns. * p<.01, ** p<.05, * p<.1.

B: Male

	Externality to Lower Secondary Graduates, Male				
	>30 obs.	>70 obs.	>100 obs	>120 obs.	>150 obs.
	1	2	3	4	5
Panel A: Formal job					
Proportion of TVET graduates	-0.291 *	-0.377 *	-0.101	-0.337	-0.020
	(0.164)	(0.199)	(0.244)	(0.310)	(0.034)
Control of Time variation					
year*quantile of urban pop	Y	Y	Y	Y	Y
R2	0.058	0.069	0.070	0.071	0.075
N	12038	8802	8053	6,947	4,424
Panel B: Permanent job					
Proportion of TVET graduates	-0.164 *	-0.199 *	0.203 ***	-0.096	-0.383 ***
	(0.091)	(0.108)	(0.059)	(0.138)	(0.012)
Control of Time variation					
year*quantile of urban pop	Y	Y	Y	Y	Y
R2	0.054	0.058	0.058	0.055	0.051
N	15032	10630	9542	8,170	5,129

NOTE: Only coefficients of the variable represents proportion TVET graduates are reported. Standard errors clustered by zone are in the parenthesis. Observations in the zones where total of TVET and non-TVET observations is less than 30 are excluded in the specification of column 1, and accordingly for the specification of the other columns. * p<.01, ** p<.05, * p<.1.

Table A6: Associations of proportion of TVET graduates with employment outcomes of TVET graduates

	propotion to (L.sec +TVET)		propotion to (H.sec +TVET)	
	Female	Male	Female	Male
	1	2	3	4
Panel A: Formal job				
Proportion of TVET graduates	-0.045	-0.341	-0.014	-0.361
	(0.201)	(0.392)	(0.219)	(0.303)
R2	0.086	0.098	0.077	0.096
N	1979	1783	1507	1258
Panel B: Permanent job				
Proportion of TVET graduates	-0.203	0.013	-0.233	-0.452
	(0.137)	(0.265)	(0.142)	(0.179)
R2	0.134	0.136	0.118	0.139
N	2384	2192	1871	1647

NOTE: Only coefficients of the variable represents proportion TVET graduates are reported. In the specifications of columns 1 and 2, proportion is defined as number of TVET graduates divided by total number of lower-secondary graduates and TVET graduates, and in the specification of column 3 and 4, it is defined as number of TVET graduates divided by total number of higher-secondary graduates and TVET graduates. Standard errors clustered by zone are in the parenthesis. Observations in the zones where total of TVET and non-TVET observations is less than 50 are excluded. * p<.01, ** p<.05, * p<.1.

Table A7: Associations of number of TVET institutes with employment outcomes of TVET graduates

	Female	Male
	1	2
Panel A: Formal job		
Number of TVET institutes	-0.004	-0.039 **
	(0.013)	(0.015)
R2	0.112	0.128
N	2523	2252
Panel B: Permanent job		
Number of TVET institutes	-0.019	-0.022 ***
	(0.013)	(0.008)
R2	0.158	0.163
N	3059	2802

NOTE: Only coefficients of the variable represents number of TVET institutes are reported. Standard errors clustered by zone are in the parenthesis. * p<.01, ** p<.05, * p<.1.